The Problem – Carbon Build-up and Cylinder Glazing

A common problem with diesel generators is carbon build up on pistons and cylinders. This is a regular complaint in larger vessels equipped with massive generators to cope with occasional peak loads, but also impacts many smaller generators over time. The problem stems from underutilization.

What happens when you run a diesel engine for too long at constant speed without a sufficient load?
Diesel engines can suffer damage as a result of misapplication or misuse - namely **internal glazing and carbon build-up**. This is a common problem in generator sets caused by running at low loads and constant RPM. Ideally diesel engines should run at least 60-75% of their maximum rated load at any given speed. Short periods of low load running are permissible providing the set is brought up to full load, or close to full load on a regular basis. Unfortunately, generators on pleasure craft are usually specified based on occasional peak loads, such as parties or full passenger loads, leaving them significantly under-utilized for the most part.

Carbon build-up happens due to prolonged periods of running at **low loads** that do not match the engine speed (RPM)**.** This can also happen when an engine is left idling as a 'standby' generating unit, ready to run up when needed or when unused sets are started and run off load as a test (still running at its working RPM). Running an engine under low loads causes lower cylinder pressures and consequent poor piston ring sealing since piston rings rely on the gas pressure to force them against the oil film on the bores to form the seal. Low cylinder pressures cause poor combustion and resultant lower combustion pressures and temperatures.

Fig 1 – Carbon Build-up

This poor combustion leads to soot formation and unburnt fuel residues which clogs and gums piston rings. This causes a further drop in sealing efficiency and exacerbates the initial low pressure. Hard carbon also forms from poor combustion and this is highly abrasive and scrapes the honing marks (Fig 2) on the bores leading to bore polishing.

Glazing occurs when hot combustion gases blow past the now poorly sealing piston rings, causing the lubricating oil on the cylinder walls to 'flash burn', creating an enamel-like glaze Fig 3 below. The combination of bore polishing and glazing smooth's the bore and removes the effect of the intricate pattern of honing marks machined into the bore surface; there to hold oil and return it to the crankcase via the scraper ring.

The result is an increased oil consumption (blue smoking) and yet further loss of pressure, since the oil film trapped in the honing marks is intended to maintain the piston seal and pressures. Un-burnt fuel leaks past the piston rings and contaminates the lubricating oil.

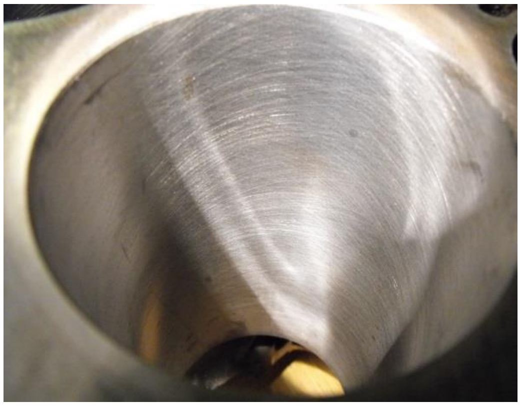

Fig 2 – Honing Marks on a healthy cylinder

Fig 3 Extensive cylinder polishing and glazing

Poor combustion causes the **injectors** to become clogged with soot, causing further deterioration in combustion and black smoking. The problem gets even worse with the formation of **acids in the engine oil** caused by condensed water and combustion by-products which would normally boil off at higher temperatures. This acidic build-up in the lubricating oil ultimately causes damaging **wear to bearing surfaces**.

It is an all-too-common cycle of degradation resulting in irreversibly damaged engines which may no longer start at all or, at best, will no longer be able to reach full power when required. **White smoke** from unburnt fuel is eventually joined by the **blue smoke** of burnt lubricating oil leaking past the damaged piston rings, and the **black smoke** caused by the damaged injectors. Unpleasant, inefficient, unreliable and costly to rectify.

Once glazing or carbon build up has occurred, it can only be cured by stripping down the engine and re-boring the cylinder bores, machining new honing marks and stripping, cleaning and de-coking combustion chambers, fuel injector nozzles and valves.

Fischer Panda i-Series generators significantly reduce the problem of carbon build up by varying the engine speed.

In a conventional constant speed generator, the frequency (e.g. 50Hz) is maintained by maintaining a constant RPM. The engine is always running at the same speed. As a consequence, there is only ever one point where torque and RPM are optimised for the load. It is therefore difficult to avoid carbon build up and all the nasty long term effects because usage patterns rarely achieve that optimum level.

Fischer Panda i-Series generators vary the speed of the motor according to the load. We use invertor technology to condition the variable frequency power generated at different RPM to produce perfect sinewave power all the time every time. In doing so, the variation to the speed of the engine allows a much broader torque/rpm/load balance (Fig 4), resulting in optimal power loading across the range. Using variable speed technology also means we can reduce the size of the engine.

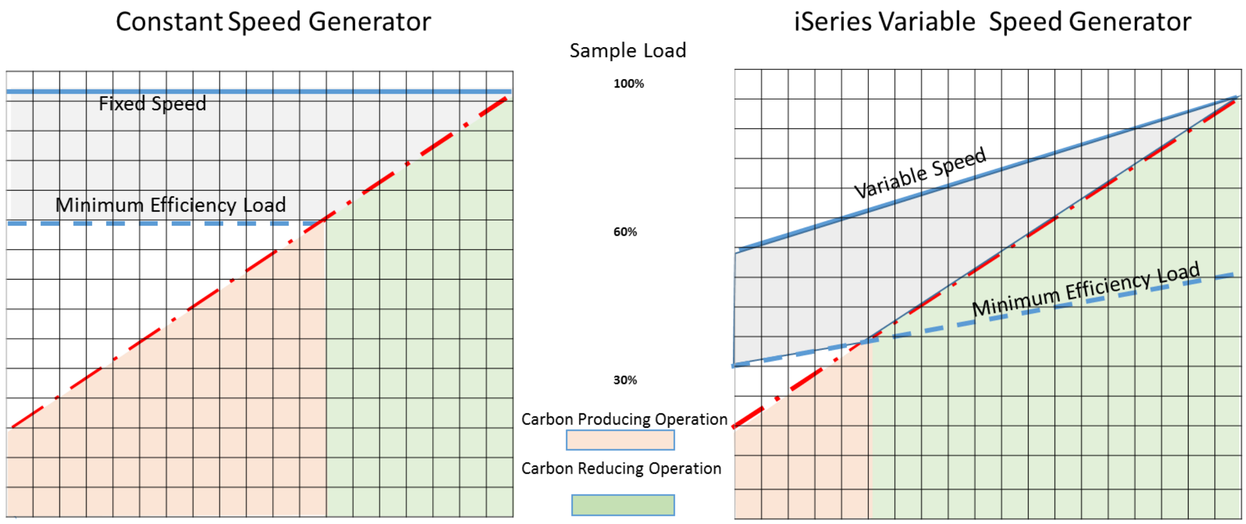

Fig 4 Extensive cylinder polishing and glazing

Where redundant or backup systems are required, the unique ability to parallel i-Series generator with a simple connection between invertors, means the design options for redundant systems become more attractive. E.g. Instead of having a backup generator configured for minimum load supporting a primary generator for peak load, 2 smaller generators can be deployed with a combined output to meet peak loads. During off peak, either generator can be switched of leaving the other to handle the normal operating loads. When running in parallel, the invertors handle the load balancing/sharing, with no need for synchronization.

The result?

- No more carbon build-up issues
- Less Weight
- Smaller Footprint
- Less Noise
- Longer Maintenance Cycles
- Consistent Performance Over Time
- Redundancy if you need it
- Reduced Total Cost of Ownership

With 10 models of Marine i-Series generators from 5kVa to 150kVa available, the design possibilities are very broad.

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